Lidar Measurements of Stratospheric Ozone, Temperature, and Aerosol Profiles at Mauna Loa

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1. INTRODUCTION

Mauna Loa Observatory (MLO) has been designated as a primary site within the Network for the Detection of Stratospheric Change (NDSC) and as such, will eventually host a complement of instruments for stratospheric observations. JPL has developed and operated a lidar system for NDSC to measure stratospheric profiles of ozone, temperature, and aerosols at its Table Mountain Facility (TMF) in southern California [*McDermid et al.*, 1990*a*, 1991]. The TMF lidar has been in continuous operation since 1988 and has undergone extensive testing and validation [*McDermid et al.*, 1990*b,c,d*]. Based on the success of the TMF lidar a new, and somewhat improved, system was constructed for deployment at MLO. This new lidar is housed in a transportable facility and was built and tested at TMF before being moved intact to MLO in June 1993 in advance of the new NDSC facility being completed there.

2. INSTRUMENTATION

The new lidar is substantially similar to that at TMF and has been fully described elsewhere [*McDermid et al.*, 1990*a*, 1991]. The major improvements for the MLO lidar are the addition of Raman receiver channels at 332 nm and 385 nm [*McGee et al.*, 1993], and an optical chopper to reduce signal-induced-noise. The Raman channels are used to obtain ozone and temperature profiles in regions of aerosol layers, a measurement that was not possible with the TMF implementation. The aerosol backscatter ratio profile is also obtained from comparison of the lidar returns at 353 nm and 385 nm, thus eliminating the need for a reference atmospheric density profile.

3. RESULTS

The lidar measurements are made at night as the cloud conditions permit. Typically measurements were obtained about three nights per week. The incidence of high altitude cirrus clouds is a limiting factor in the total number of measurements that can be achieved.

3.1. OZONE

Three separate ozone profiles are generated from the high intensity Rayleigh/Mie DIAL pair, low intensity Rayleigh/Mie pair, and Raman pair. These profiles are then combined, taking into account the location of aerosol layers and the relative errors for each profile, to make a single ozone profile that can extend from about 15 km to 60 km altitude. An example is shown in Figure 1. The error bars at the bottom of the profile are relatively large because this region is obtained from the Raman pair that has the weakest signal but is not affected by the aerosol layers.

3.2. TEMPERATURE

Temperature profiles are obtained in the same manner as with the TMF lidar except that additional information is available using the 385 nm Raman channel. This data can be used to extend the temperature profile downwards to almost 20 km altitude. As for the ozone profile, the error bars from the Raman data are relatively large but temperature profile information is obtained in a region where it was not previously possible from lidar measurements. Figure 2 shows an example of a temperature profile obtained with the MLO lidar.

3.3. AEROSOLS

The Raman-channel data at 385 nm provides a measure of the atmospheric relative density profile.

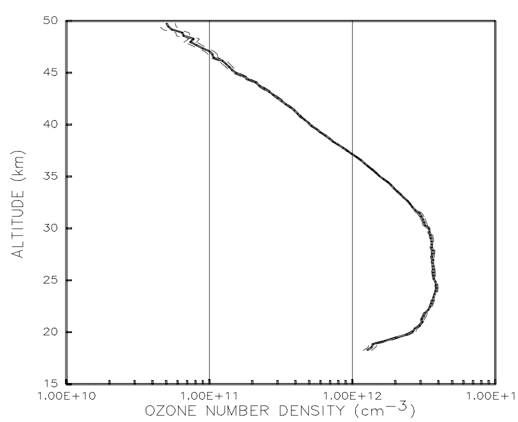

Fig. 1. MLO ozone profile for January 27, 1994.

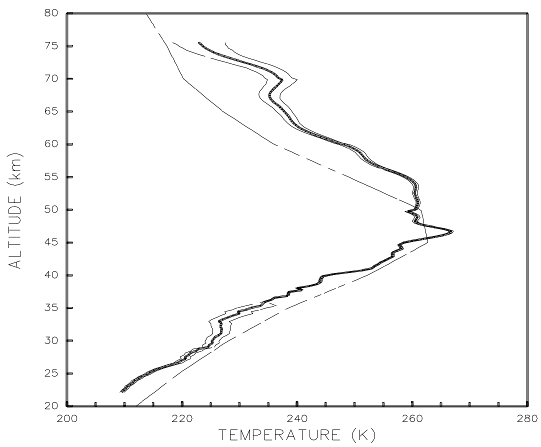

Fig. 2. MLO temperature profile for January 27, 1994. Dashed line is the CIRA reference atmosphere model.

This can be used, together with the Rayleigh/Mie scattered data at 353 nm, to calculate a backscattering ratio that does not depend on an atmospheric model such as is typically the case. If the relative density profile is normalized, for example by using results from a coincident balloon sonde, then absolute backscatter cross sections can be deduced. Figure 3 shows an example of an aerosol backscatter ratio profile. At the latitude of MLO there are still considerable aerosol layers up to at least 30 km altitude.

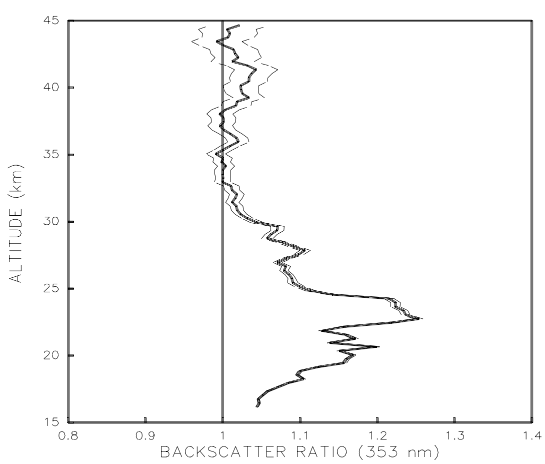

Fig. 3. MLO aerosol profile for January 27, 1994.

3.4. INTERCOMPARISONS

Figure 4 shows an example where the lidar ozone profile has been converted from number density versus absolute altitude to mixing ratio versus pressure altitude using both the lidar and CIRA model atmospheric temperature/pressure profiles and then compared with results from UARS-MLS. The two closest MLS profiles are used. For these two examples, the ozone profile has a slightly different shape but the agreement between the lidar and MLS is very good in both cases and over the entire range of the lidar measurement. This provides confidence in the Raman augmentation and in both the temperature and density measurements since both are required for the conversion to mixing ratio and pressure altitudes.

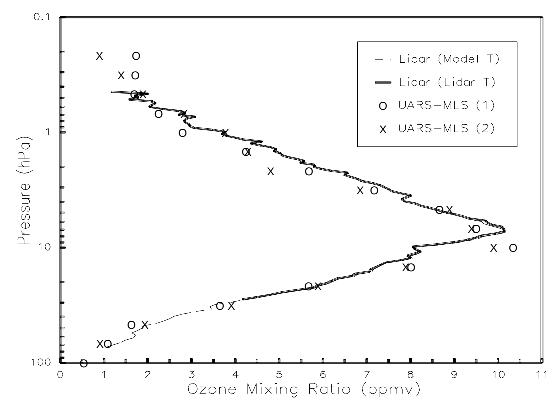

Fig. 4. Lidar MLO ozone profile converted to mixing ratio and comparison with two closest UARS overpasses (January 19, 1994).

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